USE OF

CHLORIDE OF LIME AND LIQUID CHLORINE

AS STERILIZING AGENTS.

HISTORICAL DEVELOPMENT:- Although chlorine is one of the most widely distributed elements, yet its discovery is of relatively recent date. The famous Swedish chemist, Scheele, is given credit for its discovery.

It is a heavy gas. of green color, and of very corrosive properties. It attacks violently metals and organic bodies. It is soluble in water and gives a greenish solution of irritating smell, and soon decomposes, especially when exposed to light. The gas can be liquified by compressing it in special machines, and is kept and transported in strong steel cylinders and has become a commercial article.

The bleaching power of the gas attracted first attention to its use. Prior to this most of the linen was sent to Holland and Flanders where a highly profitable but conservative bleaching industry flourished, based on a finishing process in which the use of buttermilk seemed indispensable . The first use of chlorine as a bleaching agent resulted in the rotting of the linen. But this defect was remedied by neutralizing the obnoxious properties of the gas by absorbing it first into a solution of alkali. Soda was used at first but was expensive, and after twelve years of labor Dr. Henry succeeded in substituting milk of lime, thus converting the powerful chlorine gas into a dry, portable, handy form containing 35% of efficient chlorine. By combining it with slaked lime, "chloride of lime" was formed. This is also known as "Bleach", "Bleaching Powder"

"Hypochlorite of Lime", etc.

The industrial use of chloride of lime dates from the year 1800. An interesting comparison of the amount manufactured and the price per ton is given by Mactear as follows:-

1799 - 1800	52	tons	@	$680.00	per ton
1805	147	"	@	545.50	" "
1820	333	"	@	292.00	" "
1825	910	"	@	131.00	" "
1870	925	"	@	41.50	" "

The production of chlorine was of necessity linked to the soda industry, or Leblanc process, since the initial raw material, common salt or sodium chloride, is the same for both. The greatest development of the production of chloride of lime dates from the introduction of the British Alkali Act about 1865, when the soda manufacturers were compelled to cease discharging large volumes of hydrochloric acid vapors into the air, or condensed acid into the streams. The available outlet for this bothersome by-product was the manufacture of chloride of lime; hence the development of a market for its use. From this act to prevent a nuisance has grown up an industry which now gives us not only a material for bleaching paper and textiles, but also a disinfectant and deodorizing agent.

During the early years of its development a large portion of the hydrochloric acid had to be wasted, as the market for chloride of lime was much more limited than the demand for alkalis.

About this time a new method for making soda, from salt and ammonia, known as the Solvay process, was found. In this process no chlorine was given off with which to form chloride of lime as a by-product. For this reason the old Leblanc

process was able to hold its own due to the ever growing demand for chloride of lime.

But in 1890 a new rival entered the race. The first el electrolytic works, for the electric production of alkali and chlorine was installed in Frankfort, Germany. By this process sodium chloride was split into its constituents, sodium and chlorine. The sodium uniting with the water forms caustic soda. The chlorine is used for various purposes. It is either liquified and transported in steel cylinders, or combined with slaked lime, forming chloride of lime. This is packed in barrels or steel drums, and generally contains from 30% to 40% available chlorine.

USE OF CHLORIDE OF LIME:- This new process developed very rapidly not only in Germany but in other countries more especially in the United States. In 1912 it was estimated that more than 30,000 electric horsepower were used daily in its production. In 1912 the world's production of chloride of lime approximated 400,000 metric tons.

The statistics for 1910 show the following production:-

Great Britain	110,000	metric	tons.
Germany	90,000	"	"
United States	80,000	"	"
France and Belgium	40,000	"	"
Austrai, Italy, Spain	30,000	"	"
Russia	22,000	"	"

The United States started making Chloride of lime in 1895, and the following table will illustrate the development:-

UNITED STATES IMPORTS AND PRODUCTION

OF CHLORIDE OF LIME.
(metric tons)

Year	Imports	Production
1850	2,810	
1855	4,560	
1860	7,850	
1865	10,500	
1870	10,500	
1875	22,000	
1880	34,000	
1885	43,300	
1890	45,100	
1895	45,600	
1900	61,900	10,000
1905	43,600	17,800
1910	42,600	81,000

Calcium oxychloride, $Ca\,O\,Cl_2$, is generally accepted to be the essential constituent of dry chloride of lime, and to undergo in contact with water, the following change:-

$$2\,Ca\,O\,Cl_2 = Ca\,(O\,Cl)_2 + Ca\,Cl_2$$

calcium oxychloride = calcium hypochlorite + calcium chloride

Chloride of lime is soluble in about twenty times its weight of water, leaving a small insoluble residue, mostly calcium hydrate. In an aqueous solution, calcium hypochlorite forms the only valuable constituent, the calcium chloride being inert and valueless.

In its industrial application of bleaching, deodorizing, or disinfection, chloride of lime does not act by its chlorine, but by its oxygen. Its action is not "chlorination" but "oxidation".

Chloride of lime is valued and sold on its percentage of "available chlorine", a term which indicates the whole amount of free chlorine that becomes available in decomposing chloride of lime by means of strong acid. Half

of the available chlorine is derived from the calcium hypochlorite, and half from the hydrochloric acid employed either as such or generated from the calcium chloride thru action of another strong acid.

In keeping and storing chloride of lime the factors to guard against are carbonic acid, moisture, light and heat. Therefore it should be kept in closed vessels, and in a dry cool place.

Lunge (Sulphuric Acid and Alkali, Vol 3, p.642) gives two typical analyses of commercial chloride of lime which may be of interest as follows:-

Available chlorine	37.00 %	38.30 %
Chlorine as chlorides	0,35	0,59
Chlorine as chlorates	0.25	0.08
Lime	44.49	43.34
Iron oxide	0.05	0.04
Magnesia	0.40	0.31
Alumina	0.43	0.41
Carbon dioxide	0.18	0.31
Silica, etc.	0.40	0.30
Water and loss	16.45	16.33
	100.00	100.00

The fact that the available chlorine or hypochlorate is quite easily soluble, even in fairly cold water, and the undissolved sludge of hydrated lime, silica, etc., settles readily makes it possible to obtain clear colutions of chloride of limes for a constant feed in water or sewage purification. A few simple rules should be observed:

First, do not mix too stiff a paste, otherwise a gelatinizing action takes place and greater difficulty is settling is encountered. Never mix a paste with less than one-half gallon of water for one pound of chloride of lime.

Second, it is not necessary or desirable to grind or

break up the lumps too thoroughly; the available chlorine nearly all dissolves readily and too much agitation is detrimental to prompt settling.

A stock solution of chloride of lime containing approximately 2% available chlorine may be prepared as follows:-

Three hundred pounds of commercial chloride of lime (35% available chlorine) equals 105 pounds of available chlorine, assuming a recovery of 100 pounds of this free from sludge. These 100 pounds must be contained in 600 gallons to give a clear standard 2% solution. Due allowance must be made for proper washing of the sludge, it thus contains in addition to the suspended lime and silica, a solution of equal strength to that of the clear liquid. The amount of sludge ise equivalent to about 1 gallon for each 5 lbs. of chloride of lime used.

Various forms of apparatus may be used. The essential parts are illustrated in Figs. 1, 2, and 3. This apparatus is an emergency outfit used by the State Board of Health at Monroe, Michigan during the Typhoid Fever epidemic of 1915. It consists of a mixing barrel, two storage barrels, and a dosing box. The hypochlorite solution was mixed in the upper barrel, and after time was allowed for settlement, the cleard liquid was drawn off into one of the storage barrels below, thru a pipe placed far enough above the bottom of the mixing barrel to avoid drawing off any of the settled sludge. The amount of dose applied was regulated by hand control of a small pet-cock thru which the solution flowed from the dosing box. The dosing box was fed from two storage barrels in turn and a

EMERGENCY HYPOCHLORITE DOSING APPARATUS USED BY THE STATE BOARD OF HEALTH. AT MONROE, MICHIGAN.

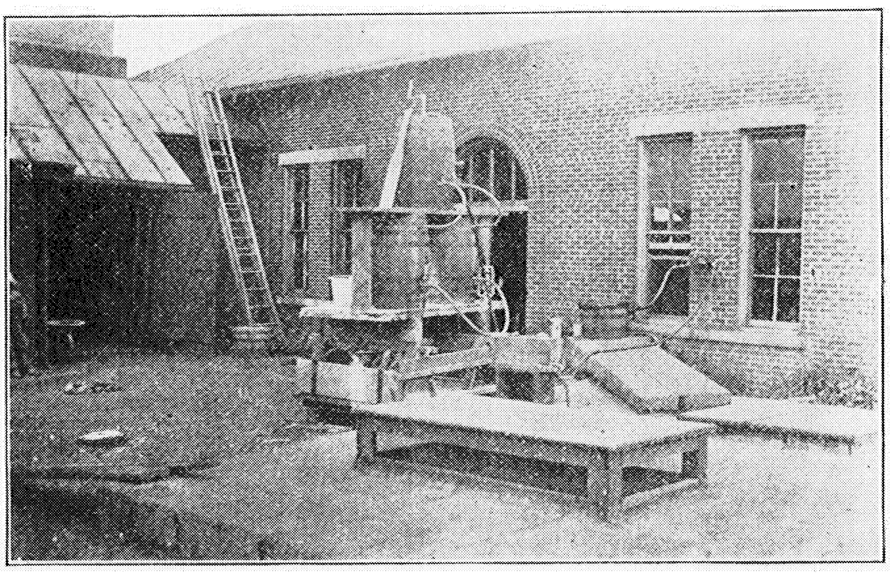


Fig. 1.

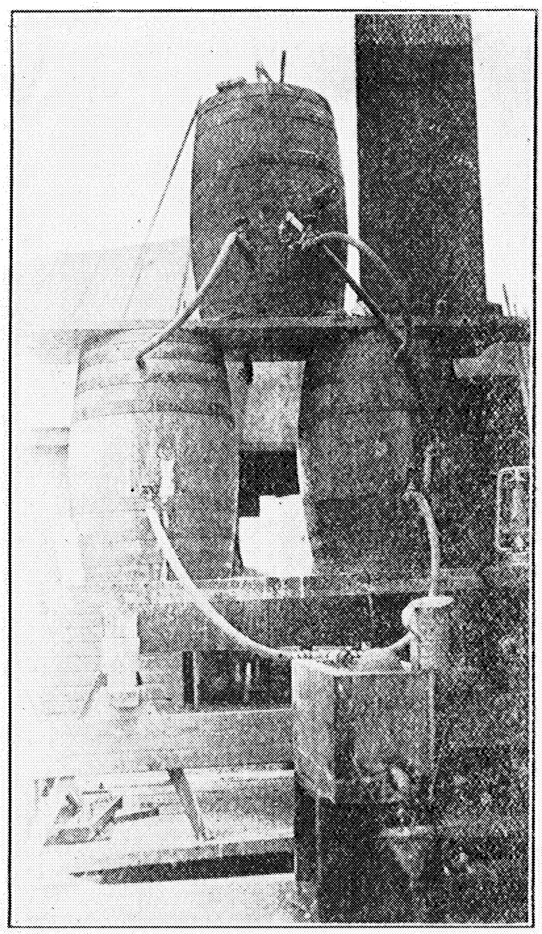


Fig. 2.
Emergency Hypochlorite Apparatus.

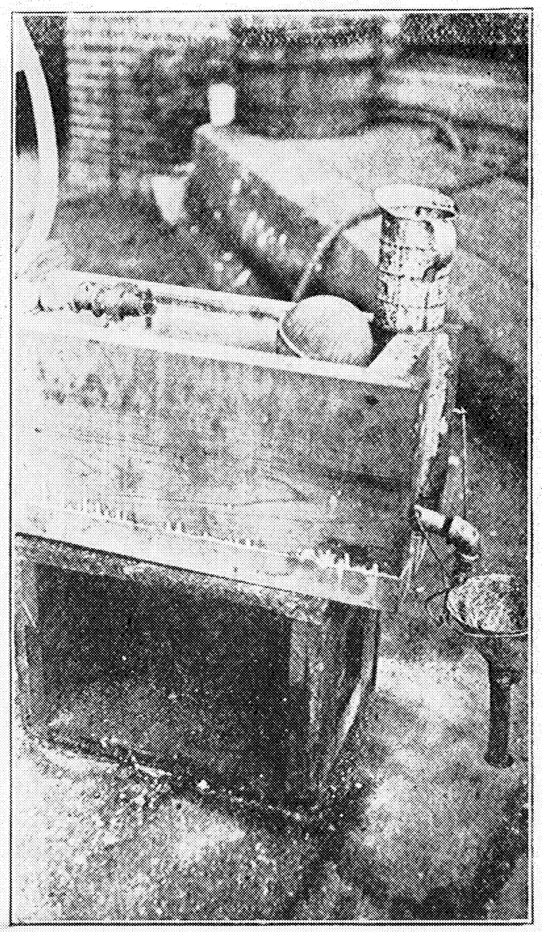


Fig. 3.
Orifice Box for the Hypochlorite Solution.

constant head of solution in it was maintained by a ball-cock. By knowing the ratio of pumping, it was an easy matter to adjust the pet-cock so any desired ratio of flow of hypo-chlorite solution might be obtained. In this case a quart measure was used and ratios figured out in pints of hypo-chlorite per minute.

For a permanent affair the tanks should be made of concrete or at least lined with cement, and adjustable means provided for drawing off the clear liquor from above as well as an outlet for removing the sludge at the bottom.

It is recommended that the solution be allowed to settle for at least 8 hours and preferably over night.

The standard stock solution thus prepared will contain available chlorine equal to ½ lb. of chloride of lime per gallon, or about 2% available chlorine or 6% of chloride of lime by weight.

The Range of Chloride of Lime

Oridinarily Used in Water Purification.

Lbs. Chloride of lime per 1,000,000 gal.water	Parts Chloride of Lime per 1,000,000 parts water	Parts Chlorine per 1,000,000 parts water	Grains Chloride of Lime per gallon of water	Grains Available Chlorine per gallon of water.	Drops Chloride of Lime Sol. 2% Chlorine or ½ lb. Chloride of lime (per gal) used per gallon of water.
2	.24	.08	.104	.005	.25
4	.48	.16	.028	.009	.50
6	.72	.24	.042	.014	.75
8	.96	.32	.056	.019	1.00
10	1.20	.40	.070	.023	1.25
12	1.44	.48	.084	.028	1.50
14	1.68	.56	.098	.033	1.75
16	1.92	.64	.112	.037	2.00
18	2216	.72	.126	.042	2.25
20	2.40	.80	.140	.047	2.50
22	2.64	.88	.154	.051	2.75
24	2.88	.96	.168	.056	3.00
26	3.12	1.04	.182	.061	3.25
28	3.36	1.12	.196	.065	3.50
30	3.60	1.20	.210	.070	3.75

LIQUID CHLORINE:- Liquid chlorine is the trade name for liquefied chlorine gas. As stated before the gas is generated by the electrolysis of brine. It is dried, compressed and cooled until it liquefies. In the course of this process the gas is relieved of all such impurities as water, carbon dioxide, oxygen, air, etc., so that the final product represents the element chlorine in its most efficient form of about 99.5 to 99.9 per cent purity.

Chlorine in this liquid state occupies only one four-hundredth (1/ 400) of the space of the gas under the same temperature conditions and is placed in steel cylinders of about eighty lbs. weight having a capacity of 100 to 110 lbs. These units of about 180 lbs. gross weight have been found to be the most convenient form for all practical purposes. The chlorine can be drawn off at will by opening the valve on the top of the cylinder. It does not matter how much or how little is taken from the cylinder, liquid chlorine being the pure compressed gas, does not deteriorate or lose in efficiency by storing, as in the case with bleaching powder.

The industry of chlorine liquefaction is of very recent date in this country, the first liquefying plant having been started only seven years ago. Since then the industry and the introduction of its product into new fields of application have grown very rapidly and it is now used extensively in textile mills, for general bleaching purposes and by the chemical manufacturing industries in various processes such as detinning, etc., after having shown

considerable advantages as to high efficiency, easier handling and higher economy than other and older methods of application.

Only after chlorine had thus been brought into a form which permitted convenient handling by the trade in general could it be considered feasible to conduct experiments with the idea of using its well known bactericidal properties for water sterilization by direct application.

These experiments have been carried on by different scientists, the first to publish any results being Maj. C.R. Darnell, who in the fall of 1910 conducted laboratory tests with very good results bacteriologically, but the method employed was not one of practical application for a large water supply. Many experiments have been conducted since that time and many good results obtained.

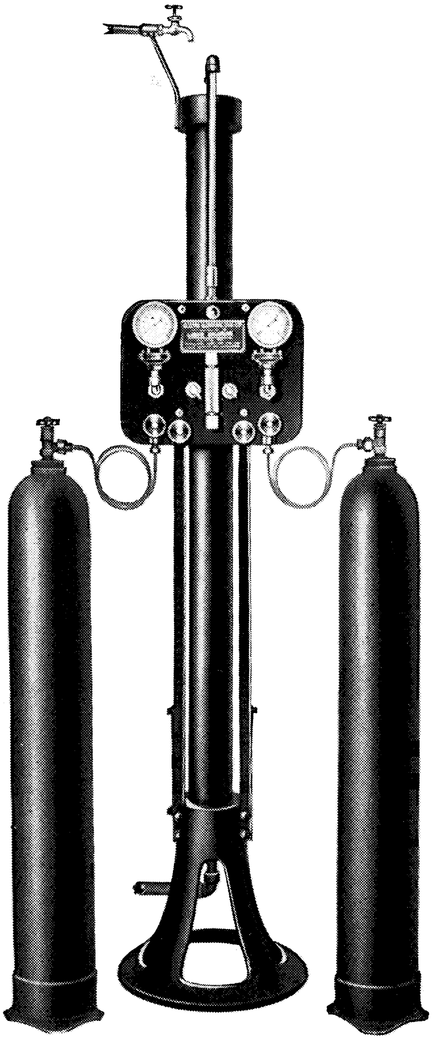
All of this experimental work demonstrated the advantageous features of the use of liquid chlorine and definitely determined its exceptional bactericidal properties, yet on the other hand the drawbacks and inefficiencies of the various methods of applying the chemical were forcibly impressed upon the minds of those who attempted its control. The difficulty arose in the development of a commercial and practical apparatus for efficiently regulating the rate of flow of the chlorine gas. Most of the failures on this score were due to the strong corrosive effects of chlorine on all kinds of metals, wood, rubber, etc.,

Various types of controlling apparatus have been developed. They are known as either the wet or dry feed. In the dry feed the gas goes direct to the water supply,

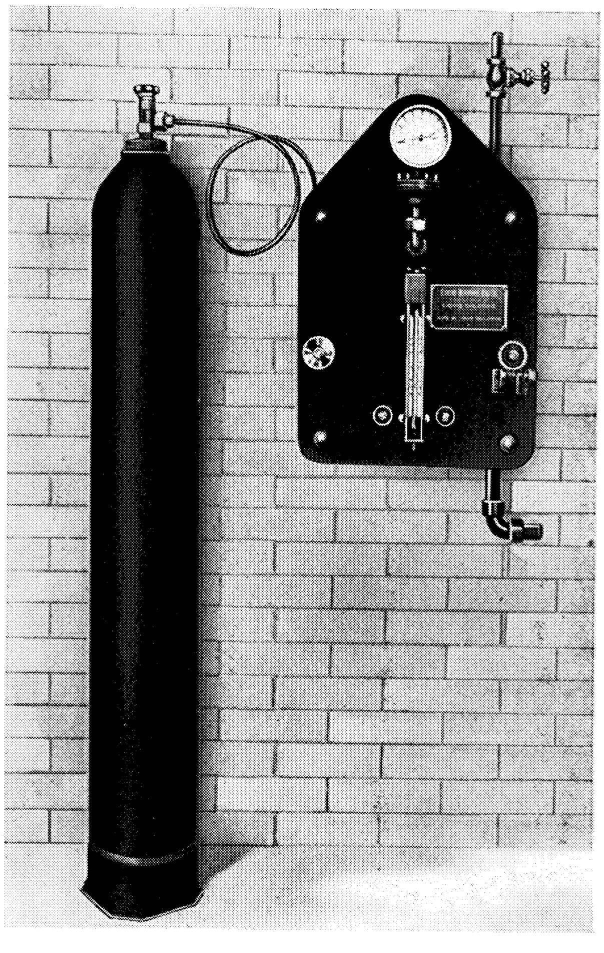
while in thewet feed the gas is first absorbed by a small quantity of water which in turn is fed into the supply.

The apparatus for the wet feed usually consists of a series of pipe coils for connecting the cylinders of gas to a manifold upon which is placed a pressure gauge with a specially prepared diaphragm for determining the initial pressure and indicating when the cylinders are exhausted. Beyond this gauge two pressure regulating devices are installed, the first being used primarily for reducing the initial cylinder pressure and maintaining it at a predetermined maximum, while the second is used for regulating this reduced pressure through a range sufficient to give the desired discharge of gas. To a branch outlet on the line between the last controlling valve and the discharge orifice there is attached a low pressure chlorine gauge which is calibrateed empirically to indicate the rate of flow of gas in pounds per hour. After passing the discharge outlet the gas is conducted by composition hardrubber tubing to an absorption tower designed to secure a thorough admixture of the chlorine in a minor quantity of water without the escape of any gas to the atmosphere. This tower may be made of stoneware, composition or any material which will resist the chemical action of the gas during the absorption process. This tower is open to atmospheric pressure at the top and any failure to secure an absolute absorption is indicated and known immediately by the presence of free chlorine in the atmosphere. The chlorinated water solution flows by gravity from the bottom of the tower to any desired point of application to the water supply. It has been found that hard rubber composition makes a very good material for

TYPES OF CHLORINE CONTROL APPARATUS.

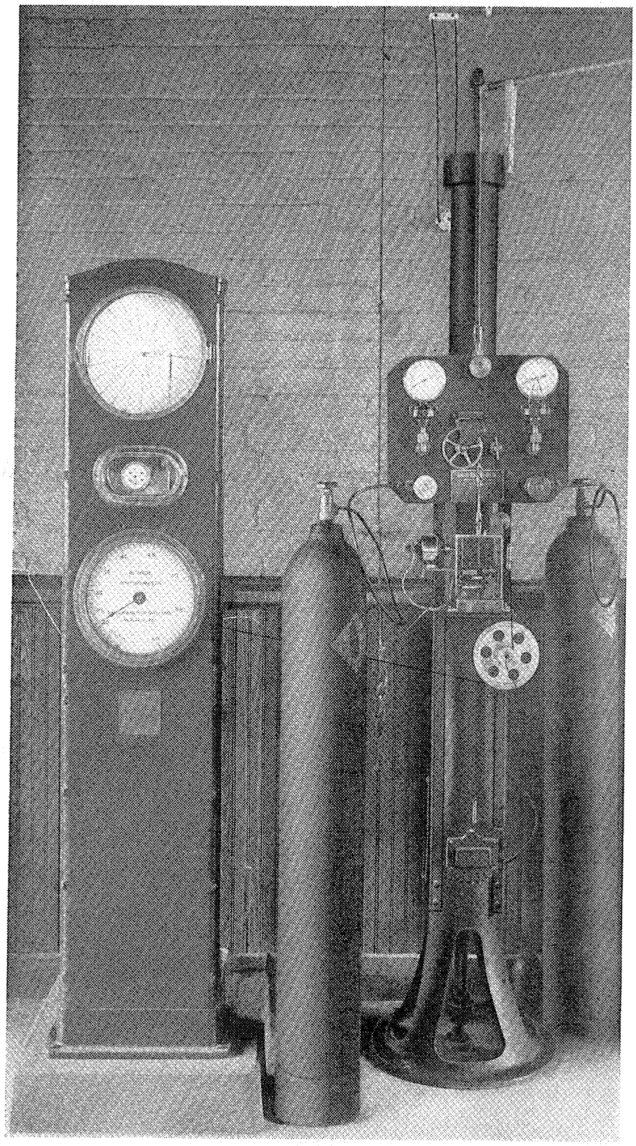


Model "C" Meter type Apparatus

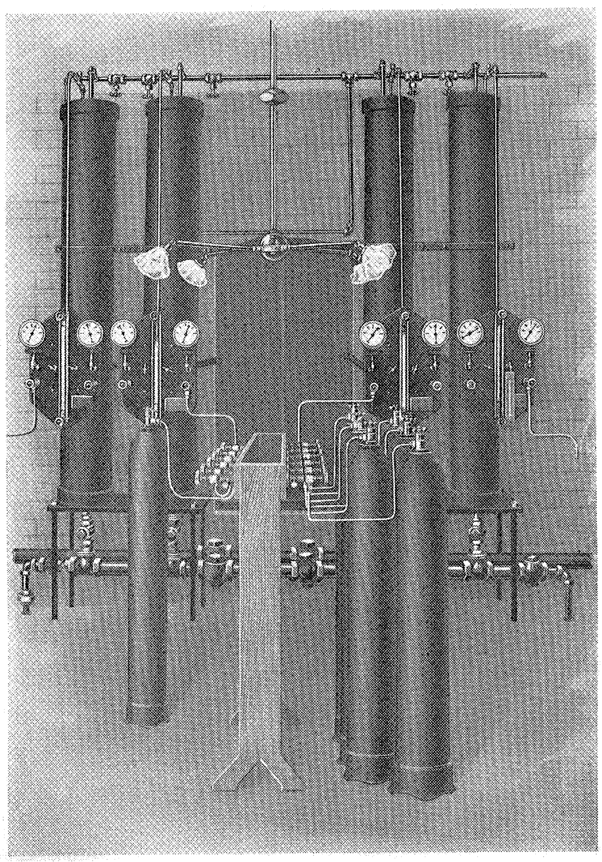


Model "D" Meter Type Apparatus

CHLORINATORS IN USE, SHOWING THE SMALL AMOUNT OF FLOOR SPACE NECESSARY.



Model "C" Automatic Apparatus at Goguac Lake, Battle Creek, Mich.



Liquid Chlorine Apparatus at Torresdale Filtration Plant (largest in the world)

the construction of these towers. They are filled with coke to m give surface for the water which trickles down from the top.

COMPARISONS:- Mr. Frank D. West, chemist in charge of the Torresdale Laboratory, claims the following advantages of liquid chlorine over chloride of lime as used at the Torresdale filtration plant:

1. That liquid chlorine is an absolutely pure chemical concentrated in small cylinders while chloride of lime is bulky, requiring large spaae for storing.

2. As to the saving in space required a one hundered pound cylinder occupies 64 sq. inches floor space. A stock for fifty days at two hundred pounds per day would occupy a space of 45 square feet five feet high. 20,000 lbs. of bleach, enoug for but seventeen days at twelve hundred pounds per day would occupy 160 sq. feet.. On a basis of 6 to 1 about ten to eleven times as much space is required for bleach as for liquid chlorine.

3. With efficient controlling devices liquid chlorine will eliminate the disagreeable odors and corrosive influences of chloride of lime; consequently the installation may be placed in position where the use of chloride of lime is impossible.

4. Liquid chlorine will retain its full efficiency over unlimited time whereas chloride of lime deteriorates rapidly. This is one of the best arguments for liquid chlorine, especially for small installations.

5. The floor space occupied by liquid chlorine plants is small, whereas chloride of lime installations require

large mixing tanks, etc. The space occupied at Torresdale for bleach treatment independent f the spcae for weighing was 22 by 16 feet; for the liquid chlorine apparatus; the cabinet is 2 ' by 4.4' and the space occupied by the towers is 10 ' by about 2'.

6. The reaction with liquid chlorine is simplified, while that with chloride of lime is complex and less effective at low temperatures.

The reactions for chloride of lime probably are

$$Ca_2 \begin{matrix} \diagup Cl_2 \\ \diagdown O\ Cl \end{matrix} + CO_2 + H_2O = Ca\ CO_3 + 2\ ClOH + CaCl_2$$

$$2\ ClOH = 2\ HCl + O$$

$$2\ HCl + CaCO_3 = Ca\ Cl_2 + H_2O + CO_2$$

Jackson (Sterilization of Cleveland Water Supply) gives the first part of the reaction as

$$CaCl_2 + H_2O + CO_2 = CaCO_3 + HOCl + HCl$$

For liquid chlorine Jackson gives

$$Cl_2 + H_2O = HOCl + HCl \quad \text{and}$$

$$HOCl + HCl = 2\ HCl + O$$

It is a question if hypochlorous acid is formed and the author prefers the simple reaction of

$$Cl_2 + H_2O = 2\ HCl + O$$

This is a liberation of 23 % by weight of nascent oxygen and which together with the powerful disinfecting action of the chlorine itself acting before it decomposes water gives the increased efficiency.

7., According to Mr. G. D Jeckson (Proceedings American Waterworks Association, 1913) one pound liquid chlorine equals

nine pounds chloride of lime; according to Mr. J. A. Kienle (Proceedings of American Waterworks Association, 1913) it equals eight. Theoretically it should equal about three, but in practise considerable available chlorine is lost from the chloride of lime and the theoretical amount is nearer one to four. At Torresdale the rate is about one to six to one to seven. It is quite possible that with careless handling and storing of bleach at small plants the figure is nearer one to eight than one to six.

8. No taste or odor appears in water treated with liquid chlorine. Maj. Darnell states that at least two parts of liquid chlorine , equivalent to sixteen pounds per million gallons must be used to give the slightest taste to Potomac river water. Mr. Huy stated that when using five pounds per million gallons a slight taste was noticed in the laboratories directly after dosing. On a test at the Connecticut Hospital for the Insane, Middletown, Conn, fourteen pounds per million gallons were used without its being noticed. It is quite possible that if the dosage is heavy enough the water will have a taste . Firguring on a basis of six to one, thirty pounds of chloride of lime would be needed to correspond to Mr. Huy's five pounds; and eighty pounds to the amount mentioned by Mr. Darnell. From a close examination of the literature on Chloride of lime the amount of chloride of lime that will give a taste to water may be estimated at from seven to twenty pounds per million gallons of water, the average figure will be from ten to twelve. At the above rating this would mean two pounds of liquid chlorine. A heavy overdose can be given without complaint.

9. Liquid chlorine does not change the character of the water by the introduction of lime salts. The lime salts will usually amount to not over one part per million.

10. Liquid chlorine necessitates no labor cost, while chloride of lime does. This is true, but a liquid chlorine apparatus requirres skilled supervision to be operated properly and is not fool-proof.

11. Liquid chlorine leaves no sludge.

12. Liquid chlorine will reduce the amount of alum needed for bacterial removal. There can be no question but that, in cases where the water is comparatively clear and where alum is used chiefly for bacterial removal, if liquid chlorine is used before filtration it will make a marked saving in the cost of alum and in many cases will not only pay for itself but will decrease the general cost of the plant. A saving of one half grain per gallon or alum at one cent per pound by the u e of one pound liquid chlorine per million gallons at ten cents means a saving of 61 cents per million gallons.

13. The feed of liquid chlorine is regular from hour to hour and the feed of chloride of lime varies constantly

Objections to Use of Liquid Chlorine:- The chief objection to the use of liquid chlorine lies in the concentrated energy of the material itself. If liquid chlorine is set free in small enclosures it will cause nausea. With ordinary common sense and judgment on the part of the operator this is not likely to happen. The greatest danger liss in faulty cylinders and faulty valves,½ If the cylinder valve were not turned off or if the cylinder leaks, it msut

be got out into the open air and the chlorine allowed to escape. Careful inspection of cylinders and valves must be made. Liquid chlorine, when it comes in contact with moisture has a very corrosive action, but this has been overcome by the use of hard rubber pipes and towers.

COSTS:- A true comparison of costs cannot be made on present prices, as the European War has caused a tremendous increase in the cost of these chemicals.

Probably one of the best comparisons under normal conditions is that furnished by Mr. West at the Torresdale plant, which is as follows:

Chloride of lime costs us from $1.22 to "1.70 per hundred pounds, the usual quotation was $1.34 and the average figure $1.40.

Taking $1.40 as a basis; we used during 1913 an average of a little over twelve hundred pounds a day or $16.80 a day for powder.

Two laborers at 25¢ per hour were employed for eight hours or $ 4.00. per day, making a total cost of $20.80 per day exclusive of repairs, sample collecting or laboratory analysis.

One hundred and eighty pounds of liquid chlorine (the amount used April 10) would cost at ten cents per pound $18.00 per day. We have now passed the worst conditions of the year, February and March, when we used 234 pounds a day or $23.40 cost.

It is expected that we will be able to reduce the amount of liquid chlorine to at least ¾ lb. per million or 120 lbs. a day. We reached this April 22.

Some supervision and handling of cylinders is required. At present the work is done by a $3.00 a day mechanic who also keeps the pre-filters in repair. His wages are charged against the pre-filter. A charge of $1.00 a day would be fair for this service. This is partly balanced by the discontinuance of laboratory analyses.

The labor cost during 1913 of $4.00 per day with its output of 180,000,000 gallons amounted to but 2.2¢ per million gallons. At Belmont and at Queen Lane the labor cost of about $1.50 per day amounted to 3.8¢ and 3¢ respectively.

At the Roxboro plant the labor cost averaged over $1.00 per day mixing; this at Lower Roxboro cost 10¢ per million and at Upper Roxboro 6.7¢ per million.

The cost per million gallons at these plants during 1913 amounted to 16¢ to 18¢. At one pound per million gallons for liquid chlorine the cost would be 10¢, or a saving of 6¢ to 8¢ per million gallons. On April 14 the quantity used was reduced to ½ lb. per million or a cost of 5¢, a saving of 11¢ to 13¢ per million.

Belmont and Queen Lane are saving a labor cost of 3.8¢ and 3¢ per million gallons. Belmont is operating at a rate of ½ lb. and Queen Lane at ½ lb., or about 5¢ each.

On April 21 the amount used at Torresdale was reduced to ¾ lb. or a cost of $13.50 per day, exclusive of a possible charge of $1.00 for labor.

In general the cost of the two processes should be about equal; if anything, liquid chlorine should prove the cheaper.

In an article entitled "The Cost of Water Purification

as affected by the War" published in the last number of the Journal of the American Medical Association the following is given:

The prices of certain chemicals used in water purification have risen greatly on account of the war. The actual amount of chemicals used in water purification plants is insignificant from the standpoint of total consumption, and at present the difficulty of the situation consists in the fact that the waterworks officials are at the mercy of the prices set by the needs of the manufacturers of explosives, and of many industrial processes. The normal price of bleaching powder, for example, on the New York Market, is about $1.25 to $1.35 per cwt., while the New York wholesale quotation, Mar.4#, 1916, were from $10.50 to $12.50 per cwt. Fortunately the advance in cost of liquid chlorine has been much less(about double the normal rate), so that chlorine disinfection may still be inexpensively carried out. It is to be hoped that waterworks officials will be on their guard against any tendency towards a lowering of the efficiency of purification because of the rise in operating expense. Here if anywhere, the motto "Safety First" has its place. Any saving effected in the quantity of chlorine or other chemicals used is trivial compared with the possible dangers of infection. The present chemical situation suggests at most the substitution of liquid chlorine for calcium hypochlorite, and where practical, of lime or iron sulphate for aluminum sulphate.

Wallace and Tiernan Co. Inc., of New York, give the following comparisons as to cost of apparatus:

The average cost of a hypochlorite dosing device is

$300.00 , including mixing tank and machinery, constant level boxes, orifices, etc.,. Thiswould be typical of the cost for a small plant, with that for larger plants, higher in proportion.

The price of chlorine control apparatus (based on twelve types manufactured by this company), will run from $350.00 to $1200.00 depending upon the type and capacityof the apparatus, and the conditions under which it is to be installed. A fair average figure for the cost of a chlorinator would be $525.00.

On this basis the average chlorinator costs $225.00 more than the average hypochlorite dosing device.

CONCLUSIONS:- From the previous comparisons of efficiency, ease of application and costs it is evident that liquid chlorine has many advantages over chloride of lime as a disinfectant in water purification. Nevertheless chloride of lime still holds a valuable position in this field and cannot be cast aside at this time. In discussing the subject MR. C. A. Jennings wrote the following:

The automobile has replaced the horse for many purposes but has not eliminated the horse. The writer feels that liquid chlorine will supplant hypo in many plants now using hypo, and that it will be installed in a large number of cities, not now using any disinfectant, in preference to hypo. However, he does not believe that hypo will be eliminated. It will probably be used for smaller installations, because of the smaller installation cost for the small and medium sized plant, and will be used to quite an extent for sewage, where the odor from the drum and the turbid solution

will not be objectionable. He does not believe thatt all the drawbacks laid to hypo are correctly placed. Many of the troubles laid to the use of hypo are really due to lack of attention; faulty design of treatment plant; incomplete mixing of the solution; expecting from the use of hypo a greater removal of bacteria than is really practicable or necessary, and the adjustment of the dose to obtain this maximum removal

Mr. Geo. C. Whipple expressed himself as follows: It seems evident that both calcium hypochlorite and liquid chlorine may be relied upon to disinfect water supply and that the two processes are about on a par as to the efficiency and freedom from taste and odor,, provided that both chemicals areadded to the water in proper amounts and with proper regularity. The advantages of liquid chlorine over calcium hypochlorite appear to lie in the field of ecomomy and convenience. It is not clear that in all cases liquid chlorine is cheaper;. Both chemicals probably have their special adaptations and with time these will become defined..

From a comparison of a large amount of data, one is greatly impressed by the very varied conditions under which these chemicals are used. Some waters being turbid and high, in organic matter while others are either filtered supplies or relatively clear waters. Therefore an estimate of the amounts necessary for any particular supply, by comparision with other supplies is impossible. The condition of the water changes from day to day not only in temperature and turbidity but in dissolved organic matter which claims first use of the nascent oxygen given off so that no definite dose can be said to be correct for all times. Any

disinfection process should be accompanied by laboratory control. In this way an economical and reliable dose may be applied according to the condition of the water.

With the remarkable advancement made with these disinfecting agencies in the past few years, and the relative ease and cost of application to water supplies and sewage affluence there is no excuse for typhoid or other water-borne disease.